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Untapped Resources . . .

WILD PLANTS

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Here is an excellent review of the challenge to *chemurgy* to explore thousands of native American plants for new vegetable resources. It is a frontier without limitations.

WILD PLANTS are much more than just the green things growing by the roadside. The "wild" category includes every noncultivated plant from the common mold to the giant Sequoia. We know what they are, but we know little about them, little of their value.

Relatively little scientific work has been done to investigate the composition and possible utilization of wild plants. Instead, we have been devoting most of our efforts to the cultivated plants, which represent only a small fraction of the total plant kingdom. This is not unnatural because it would appear that we have domesticated sufficient plants for our needs and our only thoughts should therefore be to improve them, make them bigger or better, make their yield more abundant, make them more resistant to drought, insects, and diseases. This plan has more or less governed our geneticists, pathologists, entomologists, plant explorers, agronomists, and other plant scientists.

During World War II we began to realize that our national need was no longer simple and easily satified by our domesticated plants. We suddenly faced the unpleasant question of where we were to get such things as natural rubber, tanning materials, certain starches, fats, oils, medicinals, insecticides, and fibers. We were fortunate in finding some of them and finding substitutes for others, but certainly we learned an important lesson.

We still do not know completely the total and exact composition of many domestic plants. That kind of information comes only through painstaking work by highly skilled technicians, who often work years on a single plant. At one time it was considered sufficient in making a chemical analysis of a food or feed plant to determine only its fat, fiber, and protein content. Today we would consider that to be the crudest type of examination. Now we realize that we must know much more about them, including the vitamins, sugars, proteins, oils, starches, alkaloids, and minerals they contain — in short, their complete chemical makeup. Practically no information is available as to what the hundreds of thousands of wild plants contain or for what they might be useful.

Sought-for constituents need not necessarily be restricted to those that occur in large amounts in plants because, as shown in recent years, the components that exist in only trace amounts are often of greatest importance. Typical of these are the sapogenin-yielding materials, which we hope can be converted into the drug cortisone.

Demands on Agriculture

In the past we were not forced to supplement our cultivated plant crops by the introduction of entirely new ones. With the increasing demands of our modern technological world, however, we have many more and highly specific industrial needs. More and more demands have been made upon agriculture to supply an ever-widening variety of materials that can be obtained only from plants. As a result a new science dealing with the chemical, nonfood utilization of plants developed. Farm CHEMURGY was conceived to meet the demands of industry and to help dispose of farm surpluses.

During World War II the emphasis was reversed. Then it was not a case of what we could do with crops that were in surplus, but rather how we could get the plant substances that had been imported. Many were not to be found in our cultivated plants; we were forced to look for them in our wild plants.

Need for Rubber

One of the desperately needed substances was rubber. At the outset of the war with Japan, our source of natural rubber was cut off, and our stock piles were too small to carry us through. A search for natural rubber followed. It was found in some of our native wild plants, rabbit-brush *(Crysothamnus nauseous)*, pinguay *(Hymenoxys floribunda utilis)*, guayule *(Parthenium argentatum)*, and milkweed *(Asclepias spp.)* all growing in the Southwest. In that search, two imported wild rubber-bearing plants were found — cryptostegia, from the Caribbeans, and kok-saghyz, the wild Russian dandelion from Asia. We had to have a plant source that could be developed rapidly and that would grow well on our soil. Two of the plants, guayule and kok-saghyz, showed great promise. Research workers at the Bureau of Agricultural and Industrial Chemistry developed industrial methods of rubber recovery and growing the plants on large scale operations was established by the Bureau of Plant Industry, Soils and Agricultural Engineering. By the end of the war, the plants were well on their way toward becoming another important native crop.

Natural tannins had been in short supply ever since the loss of chestnut trees killed by blight. We worried along, making up these losses with heavy imports. But the war halted imports from Italy, one of our large sources of supply. Some domestic sumacs and the bark of Western firs and hemlock were found to be potential sources of tannins. More important, a wild plant of the dock family growing in the Southwest — canaigre, *Rumex hymenosepalus* — was found to contain up to 40 per cent tannin in its moisture free roots. Someday it may become an important crop supplying a large part of our vegetable tannin needs.

Starch Sources

The war also brought the realization that we had been all too dependent upon imports for one of our common foods and important industrial needs — starch. One of these imports was tapioca. Even though we had plenty of starches, we did not know how to make them substitute for tapioca, which we use for pudding and adhesives. There was an excellent chance that a wild plant could supply a starch that would meet these needs, but we did not have the time to make a search for it. Tapioca is again available and we have succeeded in making many of the desired materials from potato starch, waxy corn, waxy sorghum, and glutinous rice but the need still remains for good sources of natural starches.

Industrial uses of starch, aside from dextrin adhesives, are many and varied. They are used for coatings and filling of textiles and papers, and the making of starch derivatives such as allyl starch and starch acetate. For some of these purposes the starches of certain plants are more suitable than those of others. It is reasonable to expect that the starches of some of the wild plants might be particularly adapted to one of these needs.

Fats, Oil, and Waxes

Vegetable fats, oils, and waxes, always of the greatest importance in nutrition and industry, are found principally in seeds, but often in appreciable amounts in other parts of a plant, including the leaves and stems. Aside from foods, vegetable oils have in the past been divided into three main classes — nondrying, semidrying, and drying. These properties are reflected in their uses — some in paints and varnishes, others in the synthetic rubber industry, others as lubricating oils for watches and other delicate mechanisms, and as lubricating oils for large motors especially those which must operate at extremes of high and low temperatures, and as the fluids in hydraulic machines. None of these uses has been satisfactorily met by mineral oils.

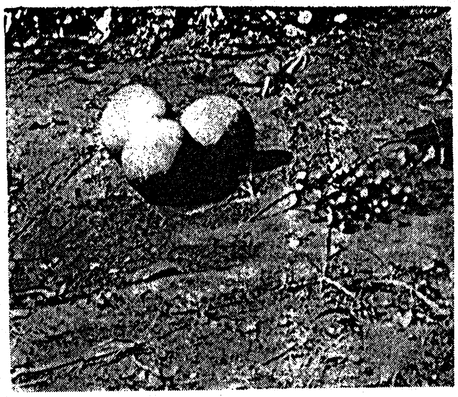
Each type of vegetable oil is usually derived from a particular plant species. No doubt some of our wild plants could supply them. From the glycerides of the unsaturated fatty acids of flaxseed, soybean, and tung are obtained the drying oils, each having its specific properties and fulfilling most of the current protective coating needs. Castor oil, a nondrying oil, is important because of its unusual properties which include fluidity at extremely high and extremely low temperatures, and its failure to gum. Because of an unusual property, it is used as a confined liquid since it does not easily leak past gaskets even when the system is under pressure.

Unfortunately, the sources of vegetable fats and oils have been restricted mainly to our cultivated oil-bearing plants. There is great promise of discovery of an untold wealth of these much needed materials in our wild plants. The finding of new oils that will have as great or greater usefulness than any of the vegetable oils now in use is very possible. The science and technology of vegetable oils is a comparatively recent development; very likely earlier people did not know the nature of the oils of the different wild plants even though they knew many of the other constituents of the plants.

Unsaturated fatty acids, such as those found in tung oil, are becoming more important. They dry better and are less subject to discoloration than the oils that contain no conjugated fatty acids. Unfortunately, practically the entire source of vegetable conjugated fatty acids is in the tropics. It can only be hoped that a study of wild plants will result in the finding of one that could be grown throughout the temperate zone and become an important crop. Only recently the oil of the wild cucurbit seed from *Cucurbita palmata* and *C. digitata* from California and Arizona was found to contain appreciable amounts of conjugated trienoic acid.

It is not the intent of this article to predict any tonnage figures of demand or supply that can be expected of wild plant oils, but it might be kept in mind that tung oil, just one of the vegetable oils, is used in amounts in excess of 100 million pounds per year. There may be a difference of opinion as to the domestic abundance or scarcity of fats and oils but when put on a world-wide basis there can be but little doubt as to their scarcity. Some go so far as to state that the wealth and health of a nation is a measure of its ability to import or produce its needed supply of fats and oils. It is quite possible that wild plants will be found that will provide the tem-

SUNFLOWER SEEDS. Glenn Briggs inspects maturing sunflowers on his father's farm at Fresno, Calif. Seeds will be used as protein in poultry feed and sold as tasty tidbits for humans.



TOMATO FAMILY. The Marglobe tomato, at left, and the small-fruit species, at right, are the parents of the new Pan American tomato developed by the Department of Agriculture at Beltsville, Md. The Pan American is even larger than the Marglobe.

perate zone with conjugated unsaturated fatty acids and that others will be adaptable for growth in the northern part of the temperate zone.

Waxes are needed as lubricants and a wax that is hard and long-wearing is needed for polishes. So far such a wax has only been obtained from vegetables, and the supply is far from adequate. A satisfactory high-melting (hard) wax has never been developed synthetically. A survey of wild plants might well disclose a source.

The question of the preservation of edible fats and oils has been intensively investigated during the past 25 years. The exact mechanism of rancidity is not completely understood, but we do know that it is the result of oxidation. Rancidity of fats and oils can be largely prevented through the use of antioxidants. Strangely enough, the antioxidants (anti-rancidity agents) are almost entirely substances derived from plants. Vitamin C has proved to be useful, but the field of antioxidants is comparatively new, and the list of known suitable materials is short. Within the past few years, N. D. G. A. (nordihydroguaiaretic acid), which is obtained from the leaf of the wild plant *Larrea divaricata Cav.*, commonly known as creosote bush, has come to be recognized as a valuable antioxidant. *(Editor's note: "Economic Potential of the Creosote Bush." October 1951* DIGEST.)

Many plant seeds can be kept for years without the rancidification of the oils they contain. Maybe that is the reason why condiments made from seeds were so popular for use in food in the days before refrigeration. It is quite likely that they contained antioxidants which diffused through the food in which they were used and kept it from becoming rancid. If we accept the idea that antioxidants are widespread, some most useful and important ones will eventually be found in our wild plants.

We struggle always to protect our fruits and vegetables from insects. We use efficient chemicals, consisting of mineral and synthetic organic poisons, but their use is limited. The insecticide may control the insect populations; it may also be causing the insects to develop a strain resistant to the particular insecticide. Another problem has to do with spray residue and its toxicity to warm-blooded animals and man. It is the latter that has contributed to making the task of the entomologist so difficult.

We want our fruit and vegetables to grow to maturity free of insects, and yet we do not want the chemical insecticide left on the fruits or vegetables in such amounts that they are harmful.

Insecticide Sources

Several insecticides, which come from wild plants, are deadly to the cold-blooded insects and animals but relatively nontoxic to man. One of these is rotenone, often called fish poison, obtained from *Derris, Lonchocarpus, Tephrosia* and *Mundulea.* Another is pyrethrum, which is derived from the flower heads of certain species of pyrethrum and others belonging to the genus *Chrysanthemum.* Today pyrethrum is used in more than 300 preparations as active insecticide; nearly all are used as sprays. The third member of this group is rather a newcomer. Ryania, obtained from the South American plant *Ryania speciosa.* It is particularly effective against the European corn borer and the sugar cane borer. Some of the interesting facts about these wild plant materials are that they are all contact poisons. They are applied to the skin of the insect either as a spray or a dust, and enough of the material is taken up by the insect by absorption through the skin to cause death.

Pyrethrum is extracted from the blossoms. Ryania is obtained from the stem wood. There is no reason to suspect that the three insecticides account for all such plant constituents which are potentially available. The need to supplement these materials with others is best understood from the prices they command. The consumption of Pyrethrum in 1939 was more than 13 million pounds, valued then at almost a dollar a pound. There is still need for a native plant as a source of this type of insecticide.

Few people realized that the making of some automobile gears of a molded fiber and a resin binder more than 30 years ago was the beginning of a whole new field of industrial enterprise. The gears were made of material obtained from the seeds of the then newly imported soybean.

Resins a Major Product

Previously, with the exception of rosin and a few gums, the resins obtained in the extraction of vegetable oils or in the processing of vegetable fibers, starches, or proteins, were considered to be undesirable by-products. That is no longer true. The resins are now used for the manufacture of alkyds, maleic resins, modified phenolic resins, and ester gums. They are used in all kinds of coatings, including varnishes and paints, and as binders for a whole new host of materials in the structural field including plywood, paperboard, fiberboard, pressed wood, and many others. In all of these applications it is necessary that the right resin and the right binder be used, and because of this there is an ever-increasing demand for new resins. One of the likely places where they might be found is in wild plants. We have not found a synthetic substitute for the imported vegetable gums and saps used in the varnish industry. Damars, exudates from the trees of the *Dipterocarpaceæ* family, are typical among these imports. More than 20 million pounds are imported annually. To find a suitable source of these varnish resins among our native wild plants would provide a much needed supply and materially aid our security.

Answer to Fiber Shortage

Like the resins, there has always been a need of fibers for specific purposes, although that does not mean that there will never be an overabundance of some particular fiber obtained from a cultivated crop. Like ramie, known to the early Egyptians, many plant fibers would be of value today but for the uneconomical methods of processing them or because of processing difficulties. With the advent of synthetic fibers, such as rayon or nylon, there is still nothing to compete with many of the natural fibers in such products as binder twine, cheap sackings, and rope. Perhaps better sources of such fibers and some new ones are to be found in native plants as yet unexplored.

A new family of fibers obtained from seaweed has been under investigation since 1939. The fibers are made from the salts formed from the alginic acid of the seaweed and such metals as calcium, beryllium, and chromium. One of its unusual uses is that it can be woven with other fibers, such as cotton, and then readily dissolved away by a process that does not harm the cotton, leaving a textile of unusual patterns and designs.

Another fiber newcomer is made from the common cattail *(Typha latafolia)* and is known as Typha. It has been made commercially from the seed pod of the plant since 1942. These unusual fibers are principally used as filling materials because of their multicellular composition which gives great buoyancy, and because of their natural coating which makes them resistant to wetting. Milkweed has also contributed a packing type of fiber, made from its floss, that was used in life jackets during the war. In England a new fiber, cotine, is being made in part from the fibers of the milkweed stalk.

Wild Plant Medicinals

Medicinals from plants are as old as man's association with them. The number of pharmaceuticals derived from plants both cultivated and wild is so vast that a separate science is required to cover that field. New, important drugs are constantly being found in plants. Only recently, in the quest to understand why cultivated tomatoes suffered from *Fusarium* wilt, a study was made of the wild tomato plant, which is immune to this wilt. The result was that the wild tomato and the cultivated cross of this wild tomato was found to contain a substance called tomatine. Tomatine proved to be effective against the growth of the fungus causing the wilt, and more important, it was also effective against some of the fungus diseases of man. The analogy can be carried on indefinitely. Wild plants could have survived throughout the centuries only through their development of antibiotics similar to that of the wild tomato.

Another but quite different situation was that of the development of penicillin. It was only the selection of the proper plant nutrients, in this case corn steep liquor, for use in the culture medium that increased the growth of the mold *Penicillium* to the extent that it became an important industrial commodity.

An outstanding development of a new drug from plants was that of rutin, a flavonol glucoside. Rutin was found effective in reducing abnormally high capillary fragility and permeability and today it is finding uses in many disorders. The drug has been found in a number of cultivated plants and some, such as buckwheat, contain it in comparatively large amounts. There is a possibility of finding a wild plant that could be developed for even better yields of the drug.

A recent and truly great discovery of modern medicine is the drug cortisone. Its source is a small animal gland, the adrenal, and the world supply is utterly inadequate for the treatment of the overwhelming number of cases of rheumatoid arthritis, one of several diseases for which cortisone is found to be a palliative agent. Even though the total synthesis of cortisone has been announced recently, the possibility of its ever being a practical method of preparation is extremely remote. We must depend therefore on natural sources for precursors. If animals cannot supply it in adequate amounts, we have only the vegetable kingdom to turn to. Cortisone belongs to a class of chemical compounds known as steroids, which are to be found in plants. Not all plant steroids will do, however. Only those known as saponins hold any promise. Strangely enough, the only known plants that have any appreciable amounts of saponins are wild plants. The mere location of the plants with the correct saponins will not be sufficient, because the chemist by a long and tedious process must then convert them into an active drug. The discovery of the drug, together with the knowledge that there is an excellent chance that plants will provide an adequate source of material from which enough of it can be made to meet the demands, has caused an intensive search for wild plants that may contain the correct primary substance.

Search for Cortisone

The search that is now going on to find a plant substance that can be converted into cortisone is spectacular. Saponins occur in some 100 plant families, particularly those known as soap plants whose juice causes water to froth like soap on agitation. These plants have long been used by the Indians as soap substitutes. One of these, the California soap plant or amole, *Chlorogalum pomeridianum,* was also used as a fish poison, another indication that it was of the correct type of saponin, for these should exhibit poisonous characteristics. Having located some plants that show promise of containing the correct steroids which would serve as a precursor for cortisone, it is an easy matter to find other plants of the same family and species and check them for their steroidal content. Two of these are the Mexican yam, *Dioscorea composita,* and the Agave, *Agave toumayana.*

Potentials Assured

That we shall ever discover any of the potentialities of wild plants or that they may become some of our major or supplementary crops can be assured by pointing to results already achieved, even though these results are based mostly upon cultivated plants. Many products have been developed from cultivated plants as the result of the combined scientific efforts of private industries and foundations, state research institutions, and federal laboratories. Similar developments with the same scientific approach to the almost totally unexplored world of wild plants should be expected. The federal government, through its Bureau of Agricultural and Industrial Chemistry with its four regional laboratories, has been concerned during the past 12 years with the industrial utilization of surplus farm commodities. They have in a large measure been successful, and this success is directly traceable to examinations made of the composition of these surplus plants and the resultant uses which were developed for many of them.

With the discovery of new uses an accompanying increase in the demand for the plants has developed. With the discovery of the medicinal applications of rutin, buckwheat may again become a crop of economic importance, rather than one for a run-down farm. The

MATURE MILKWEED PODS. Packing fiber made from milkweed floss was used in life jackets during World War II. Milkweed stalks form part of new English fiber "cotine."

discovery of the high tannin yield of canaigre gives indications that it may become an additional crop for the Southwest. Knowledge of the wide variety of technical uses for tung oil has meant that the small plantings of tung trees along the Gulf of Mexico are inadequate to supply the need for its type of oil. To help meet our requirements for unsaturated oils rich in linoleic and oleic acid, we have established on a small scale crops of sunflower and safflower, *Carthamus tinctorius,* because of their high yields of these oils.

Plants with seeds rich in oil have long been used as foods by the Indians. The seeds of the sunflower were eaten raw, dried, roasted, or made into cakes by tribes throughout the United States. Their chief value, of course, was their high oil content. Only recently have we begun to consider the sunflower a crop, even though a minor one. The reasons are two-fold. We have succeeded in developing a fast growing dwarf variety that can be handled with grain harvesting machinery, and we have now learned that the oils are particularly valuable because they are free of linolenic acid which permits more precise control in converting them to a hardened oil by hydrogenation. The sunflower seed has also been found to be an excellent source of vitamin B_1 and of niacin.

Useful Domesticated Plants

Of the thousands of plants found in the United States few have become cultivated. The domesticated plants include pecans, *Carya pecan;* blueberries, *Vaccinium corymbosum;* raspberries, *Rubus idæus strigosus* and *R. occidentalis;* dewberries, *Rubus flagellaris;* blackberries, *Rubus ursinus;* strawberries, the result of the hybridizing of two European and two American species, *Fragaria virginiana;* grapes, *Vitis;* sunflowers, *Helianthus annuus;* some plums, *Prunus americana;* and the gourds, *Cucurbita pepo.* All other cultivated plants have been imported, usually from countries where they had already been domesticated. Our small grains and vegetables are mostly imports from the middle East; many of them originated in Turkey.

Research Project

Why these thousands of wild plants have been passed by when their mere presence indicated that they had been acclimated to this environment through centuries is not easily answered. Undoubtedly it is because the early settlers were not accustomed to the plants as food and did not see fit to propagate them in competition with the European food plants brought with them. Industrial use of the wild plants has been restricted by lack of fundamental research which would give information as to any useful constituent present in them.

To find out more about the multitude of unexplored wild plants, we could adopt several procedures. We could approach it with a plan for an across-the-board chemical analysis of any or all wild plants selected at random, making as complete an analysis of each plant as possible. Or, we could make screening tests. Either would give us volumes of analytical data of great scientific interest and value, but some of it might have little practical importance. The screening analysis would perhaps show whether or not the plant contains some of the constituents desired, but would not give opportunity for recognition of any new constituents of the plants which might be of greater importance.

Another, and perhaps surer way would be to direct the search to specific substances and to select only the plants that belong to the genera among whose species there are some which are known to contain these sought materials. That, too, would be subject to some criticism. The analysis of such nuisance plants as the mesquite of the Southwest, the sage brush of the West, or the thorn apple of the Northeast, might result in finding some constituent of enough importance to commerce to give the added incentive for their harvest and so lead to their ultimate eradication as nuisance plants.

Economic Needs Guide Research

The most fruitful approach might be to search for compounds or constituents for which there already exists an economic need. For many constituents, this is not as hit-and-miss a selection as might be supposed. Actually, people throughout the centuries have been making casual examination of many of our wild plants, and while they do not give much information, they do offer some guideposts. For example, people learned about guayule by noting that Mexican peons played a game with a very resilient ball. The ball proved to be of pure rubber, obtained by chewing the bark of the guayule.

Another interesting minor crop came into being through native use of a plant. Explorers into South America observed that the Indians were able to catch fish by poisoning them. This was done by throwing into a fish pond a water steep of a native plant. The fish were stunned and rose to the surface where they were easily collected by the Indians for food. The poisoned fish never appeared to cause harm to those eating them. This gave rise to investigations which disclosed that the plants contain the substance, Rotenone. It was not until 1920 that the use of rotenone as an insecticide became common and since that time its use has grown to several million pounds annually.

Wild Plants as Crops

Work on wild plants with the prospect of adding new crops to our agricultural program and of supplying the demands for new materials must not be limited to plants of the United States but should eventually include all of the wild plants of the world. Many believe that a study of wild plants will mark a new era in American agriculture.

For many years the Department of Agriculture has searched all over the world for plants that show promise and has brought many of them to these shores. Most of the introductions were to serve research workers in plant breeding, physiology, agronomy, horticulture, and other fields of pure and applied botanical science in the improvement of our existing cultivated crops or for the introduction of cultivated plants from other parts of the world. Few wild plants were imported for chemurgic uses because there was a lack of means whereby they could be evaluated. Plant introduction work is being greatly expanded through additional funds made available by the Research and Marketing Act of 1946, but even with increased facilities for conducting plant explorations there still remains the problem of appraisal of the plants imported.

Through the chemical investigation and evaluation of both imported and domestic wild plants, constituents will be found that will be of value to farm CHEMURGY, to medicine, and to nutrition which should result in additional crops. These crops may then be substituted for those which may be in surplus or they may be better adapted to some soils than the crops growing on them. The enormity of a project that would some day provide a complete catalog of the constituents of wild plants, does not minimize its importance.

"Renewable Resources"

Agriculture is America's greatest natural resource. "Crops," says Dr. F. V. Cardon, Agricultural Research Administrator, Department of Agriculture, "are renewable resources. For our own protection we must speed up our efforts to develop more renewable resources. This places a heavy responsibility upon research, both in agriculture and industry."